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AUTHOR Keller, Joyce A.; Schallert, Diane L.
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ABSTRACT

The proposition that the mastery of complex tasks embodies several components was studied for 236 students in an undergraduate introductory financial accounting course. A new curriculum was developed for the course that included in-depth exposure to the actual financial statements of a company and the understanding of the structural relationships among the accounts. Examinations administered during the semester determined students' basic knowledge as well as inferential understanding of structural relationships among accounts. On the final examination, students encountered questions about real-world companies that were considered far transfer complex task questions. Results indicate that basic factual knowledge is not enough to cause transfer, and that far transfer can occur even when factual knowledge has not been fully acquired. The failure of even the top students to achieve overall mastery suggests the need for skills to become automated before full transfer can occur. Structural transfer appears content dependent. An understanding of structural relationships facilitates the far transfer that complex knowledge implies. Although it was not specifically tested, it appears that students should be exposed to real-world contexts involving far transfer complex knowledge in order to learn to deal with information that is less than obvious. Two tables present study data, and an appendix contains five sample test questions. (SLD)

"Complex Knowledge Mastery: Some Propositions"

Joyce A. Keller, Texas State Auditor's Office
Diane L. Schallert, The University of Texas at Austin

INTRODUCTION

The question of how students achieve mastery of complex knowledge has been addressed from several vantage points. Complex learning situations reflect situations where the knowledge learned involves a number of aspects intricately related and where the application of that knowledge in the context of actual use is not obvious. Early studies of mastery by Gagne posited a hierarchical building block approach to complex task mastery (Gagne, 1961, 1962). By contrast, others have suggested that the ability to handle complex tasks occurs if learning takes place through judicious use of situated examples that are presented in contexts true to their eventual use (Brown, Collins, and Duguid, 1989; Spiro et al., 1987). The cognitive apprenticeship model of Brown et al (1989) is premised on the assumption that one learns best in a situation comparable to a craft apprenticeship. Students are initially and continually motivated by problems whose contextual parameters are closely related to real-life, and as such, gain confidence in their ability to find solutions. With the assistance of a teacher or coach, students are guided in their problem solving. Because the search for the solution involves the retrieval of rules, principles are understood and evaluated in the context of applications which are often complex; this increases the likelihood that principles and real-life applications will be appropriately associated in future situations. The result is that principles become useful and used knowledge.

What appears to be a related issue is that of knowledge transfer, specifically of far transfer. And while major streams of studies suggest that transfer often occurs on the basis of perceptually similar characteristics (Chi, Feltovich, & Glaser, 1981; Brown & deLoache, 1978), researchers have also accumulated evidence for transfer founded on structural relational similarities (Chi, Feltovich, & Glaser, 1981; Clement and Gentner, 1991; Brown, 1991; Robertson, 1990; Holyoak and Thagard, 1989). Clement and Gentner have posited that systematicity or the identification of commonalities is more likely to clarify shared structural characteristics and so facilitate analogical transfer.

Recently Brown (1991) has suggested that it is in the absence of foundational knowledge that transfer purely on the basis of surface cues is likely to occur. Thus, she proposes that transfer is domain specific, relying upon some mastery of basic knowledge of the structural parameters of a specific content area; it is therefore content dependent. Novick and Holyoak (1991) found that there were two important predictors of analogical transfer in solving math word problems: knowledge of the numerical mapping indigenous to the specific problem sets and mathematical expertise. However, knowledge of numerical mapping alone did not ensure knowledge transfer. Moreover, the authors also found that mathematical expertise by itself was not enough to account for the results in analogical transfer. Finally, general analogical reasoning ability could not predict any of the outcomes. All these findings suggest that there is a complexity of expertises that are combining to produce transfer.

PROPOSITIONS

In the present study, we propose that complex task mastery embodies several components and explain the question of complex task efficacy through the incorporation of the above lines of research. This

study therefore presents the following propositions:

(1) A complex situation may be considered a specific and perhaps the most sophisticated case of far transfer and involves a certain process of thinking or set of thought processes (inductive, deductive, inferential) concerning structural relationships; it therefore implies a systematic approach to the elements of a domain and how they relate.

(2) These structural relationships (causal, analogical, etc) are domain specific and so require some degree of mastery of understanding before such far transfer can occur. Thus far transfer in a complex situation is content dependent.

(3) Basic factual knowledge is not enough to cause this transfer.

(4) This transfer can occur even when basic factual knowledge has not been fully acquired.

(5) Successful transfer of knowledge to complex situations requires prior experience of similarly complex situations.

This study brings evidence for the above tenets from the field of financial accounting and involves 236 students in an undergraduate introductory financial accounting course.

PROCEDURE

Setting:

The field of financial accounting embodies a logical system of accounts that reflect real-world financial events. Its organization focuses on the presentation of the systematic application of this logic to financial transactions in the form of several officially mandate financial statements: the income statement, the balance sheet, and the statement of cash flows. Though not required, publicly-traded companies typically include a statement of shareholders' equity. While there are rules governing the formatting and composition of these statements, there is still considerable latitude such that each set of statements forms a uniquely unified compendium representing the financial status of the company. The analysis of such a set of financial statements is viewed as a complex activity and necessitates considerable understanding of the relationships among statements and their concomitant accounts in order to infer critical information about the financial status of the company.

Tasks:

As noted in Brown, Collins, and Duguid, the content of courses is often taught without references to its ultimate context for use. Introductory financial accounting courses are no exception. In an effort to bridge the gap between textbook and real-life applications, a new curriculum for this course was developed that included in-depth exposure to the actual financial statements of a company chosen by each student and to some analysis via a small-group exposure to the financial statements of a real-world company. Further aspects of the curriculum involved explication of the structural relationships amoung accounts, presented primarily during the middle 8 weeks of a 16 week semester. Whenever a new concept was introduced, the students were shown examples of its configuration on the statements of actual companies. Homework problems during this middle period incorporated information extracted from the statements of real companies

and presented to students in its extracted form. Examples of homework exercises can be found in Appendix A.

Three exams were administered during the semester: the first one, four weeks into the semester; the next, at 12 weeks; and the final exam. They were comprised of questions for this research study as well as non-research related questions; reported here are the former. The first two exams included questions concerning basic skills as well as some questions requiring inferential understanding of structural relationships among accounts. These structural relational questions resembled the physical formatting of some homework and class problems and are considered to be near-transfer questions. For the final exam, students were given the financial statements of 4 real-world companies; questions on this exam bore no perceptual similarity to previous homework or exam questions. Thus they could be considered far transfer complex task questions. Other questions required knowledge of basic skills only, though all questions required the ability to read the statements of real companies. All exams contained some difficult items to avoid ceiling effects. Examples of problems presented on the three exams are given in Appendix A.

RESULTS

Student scores on the second exam were divided into high and low mastery, using a mean-split, for basic skills mastery and again for structural relations mastery. This resulted in 4 groups of students, categorized with respect to basic skills mastery and structural relational understanding (see table 2). The results are presented as they relate to the propositions listed above. Information regarding personal characteristics of students is given in Table 1.

Proposition 3: Is basic factual knowledge enough to cause far transfer?

Two sets of evidence relate here. Note first of all that there is a group of students who were mastering basic skills (75% versus the class mean of 65%) but who scored low on transfer (48% versus the mean of 61%). Likewise, by the final exam, this group scored at the class mean on basic skills questions (58%) but still low on transfer (33%). Thus, basic factual knowledge is not enough to cause near or far transfer.

Proposition 4: Can far transfer occur even when basic factual knowledge has not been fully acquired?

Table 2 reveals that there is a group of 20 students who were already evidencing mastery of structural relations by the second exam (mean percentage score: 74%) even though these students were low in basic skills mastery (52%). This group also scored second highest in far transfer mastery on the final exam (44%) but at the class mean on basic skills (58%). Thus, far transfer can occur even when basic factual knowledge has not been fully acquired.

Proposition 2: Is structural transfer content dependent?

Analysis of variance, comparing the scores of the 4 groups on the structural relational questions on the first exam showed no significant group differences ($F=.05$, $p>.98$). While students evidenced basic skills mastery by exam 1, they had not been exposed extensively to the structural relationships in the accounting domain; thus, by exam 1, they were not able to infer these relationships. However, by the final exam, there were group differences in ability to perform far transfer, based upon their mastery of structural relationship on the second exam ($F=11.36$, $p>.0001$). Further, the correlation between SAT-quantitative subset scores and the structural relationship questions on the first exam is not significant ($r=.125$, $p>.152$). So even

students who have high quantitative aptitude were not necessarily able to answer such questions on the first exam. This result held true for the correlation between grade point average and successful performance on knowledge transfer questions on the first exam ($r=.06, p>.45$). This is further evidence that structural transfer is content dependent. By the final exam, both GPA and SAT-Q scores were significantly correlated with performance on transfer questions ($r=.31$, $p<.001$ for GPA effect and $r=.33$, $p<.001$ for SAT-Q effect).

Proposition 1: Does understanding of structural relationships facilitate the far transfer that complex knowledge implies?

Given that the final exam required cognizance of the complexity of real-world financial statements, students who evidenced understanding of structural relationships also did better overall on that exam than did students who had not acquired understanding of structural relationships ($F=46.95$, $p>.0001$). This is partially supportive of proposition 1. Full support would require the high-high group to achieve high overall mastery of the final exam on an absolute scale, which they did not.

Proposition 5: Successful transfer of knowledge to complex situations requires prior experience of similarly complex situations?

Because all students were exposed to the statements of real companies on an equal basis throughout the semester, it was not possible to test if such exposure would make a difference in performance on complex tasks, the final exam. In an effort to determine this, other teachers of the traditional course,where real-world statements were not introduced, thus making these course sections appropriate comparison groups, were requested to include two experimental questions on their final exam. However, the teachers refused, stating that their students would not be able even to begin to answer them.

DISCUSSION

A theory for how one successfully addresses real-world complex situations requiring mastery may by definition be complex and so may not be amenable to simple explanations. This paper has presented five propositions related to such complex task mastery. In line with the findings of other research (Novick and Holyoak, 1991), this study also found that basic factual knowledge is not enough to cause near or far transfer (Proposition 3). There was a group of students who scored high on basic skills mastery on the second exam but who were low on structural relations mastery. However, this study also found that transfer can occur even without full basic skills mastery (Proposition 4). There was a group of students who were able to transfer their knowledge even though they had not acquired all of the details of the fundamental knowledge facts. More importantly, far transfer is more likely to extend to situations requiring complex knowledge mastery when mastery of structural relationships exists (Proposition 1). Those students who were superior in structural relational understanding by the second exam were more capable of performing far transfer activities on the final exam than were students who had not achieved such a high level of structural relational mastery. This structural understanding also is domain specific and so rests upon mastery of domain-specific structural relationships (Proposition 2). There was no initial difference in the high-low structural knowledge groups in performance on structural knowledge questions given on the first exam nor were there significant correlations between SAT-quantitative scores or grade point averages and ability to solve such problems on the first exam. As with the results of the Novick and Holyoak study, both of these components did relate to final performance, once learning had taken place. While not tested, it appears to be essential that students be exposed to real-world contexts involving far transfer complex knowledge in order to become familiar with finding information that is less than obvious (Proposition 5).

The failure of even the top students to achieve overall mastery may imply the need for skills to become automated before full transfer can occur, as has been found in some research (Cooper and Sweller, 1987). However, the present research at least supports the proposition that significant far transfer to real-situation complex tasks did occur. A more rigorous testing of the five propositions posited in this paper, with perhaps some provision for automation, may further clarify the dimensions involved in such mastery.

Joyce A. Keller is Assistant State Auditor with the Texas State Auditor's Office. Her address is

P.O. Box 12067
Austin, Texas 78711-2067
(512)-479-4865

Diane L. Schallert is an Associate Professor in the Department of Educational Psychology, The University of Texas at Austin, Austin, Texas 78711. Her telephone number is (512)-471-4155.

Table 1

Group (Basic Skills/ Structural Mastery)	N	SAT-Quant	GPA	Had Previous Accounting
Low/Low	78	537	2.11	20%
High/Low	39	588	2.34	16%
Low/High	20	550	2.21	10%
High/High	108	601	2.78	14%

Table 2
(Mean percentage scores on basic and structural subsets)

Group (Basic Skills/ Structural Mastery)	Exam 1		Exam 2		Exam 3	
	Basic	Structural	Basic	Structural	Basic	Structural
Low/Low	42	36	39	40	52	33
High/Low	49	35	75	48	58	33
Low/High	44	34	52	74	58	44
High/High	54	36	84	81	64	52
Class Mean	45	35	65	61	57	42
Number of questions	7	5	12	9	11	6

APPENDIX A

Homework problem previous to the first exam:

On January 15, 1989 a company purchased furniture and fixtures for their store at a cost of $30,000. The company paid cash of $20,000 and gave a one-year note for the balance, 6% interest perannum, payable at maturity. The estimated useful life of the furniture and fixtures is 10 years, with no salvage value. The adjusting entries at 12/31 will include

A. a debit to interest expense and a credit to interest payable
B. a debit to interest expense and a credit to cash
C. a debit to depreciation expense and a credit to furniture and fixtures
D. a debit to notes payable and a credit to cash
e. a debit to interest receivable and a credit to accumulated depreciation

Question from first exam:

On 1/31/89, the ABC Co purchased 35 new computers and 35 paper stands to set next to the computers from the XYZ Company. ABC paid $50,000, with $20,000 in cash, and the rest to be paid on 1/31/90 along with a 12% charge for interest. Assuming XYZ's fiscal year ends on 12/31, XYZ's journal entry on 1/31/90 included which of the following?

A. a debit to cash for $33,600 and a credit to interest revenue for $3600
B. a credit to interest receivable for $3300 and a credit to note receivable for $30,000
C. a credit to interest revenue for $3600 and a credit to note payable for $30,000
D. a debit to cash for $33,600 and a credit to interest receivable for $3600
E. both C and A are correct.

Homework problem before second exam:

The following note is taken from the 1987 annual report of Citicorp. (Some figures have been omitted).

Changes in the Allowance for Possible Credit Losses
(in millions of dollars)

	1987	1986	1985
Balance at beginning of year	$?	$ 1,235	$ 917
Deductions:			
Net consumer credit losses	1,024	958	?
Net commercial credit losses	473	413	?
Additions:			
Provision for possible credit losses (Bad Debt Expense)	4,410	?	1,243
Other (including reinstatements)	?	9	37
Balance at end of year	4,618	1,698	1,235

The amount of 1985 writeoffs is

A. $ 917
B. $ 962
C. $ 1235
D. $ 1243
E. cannot be determined from the information given.

Question from second exam:

ALLOWANCE FOR POSSIBLE LOSSES

	1984	1983	1982
Beginning Balance	$6,608,286	?	$4,217,922
Deductions:			
Loans charged off	2,103,627	?	$2,228,245
Add:			
Recoveries of loans previously charged off	?	$ 530,000	$ 495,336
Provision charged to operating expense	4,000,000	4,040,000	2,188,701
Ending Balance	9,242,654	?	?

The amount of 1983 charge-offs was

A. $2,635,428
B. $4,040,000
C. $4,673,714
D. $6,608,286

Question from final exam:

Using Accounts Receivable information from the balance sheet and Provision for Uncollectibles information from the Statement of Cash Flows, and assuming that 1989 reinstatements of accounts were $0, what were Browning-Ferris' 1989 write-offs?

A. $ 3595
B. $ 9230
C. $10863
D. $12825
E. $14458